

relates to high performance multiplayer resist structures including bilayer and top surface imaging (TSI) methods and fabrication thereof.

Applicant notes further that the most typical underlayer used in bilayer and TSI has been cross-linked novolac/diazonaphthoquinone (DNQ) systems. The prior art novolacs have many disadvantages as described. In particular, high temperature (>200C) is needed to cross-link, the system must be carefully designed and controlled to prevent resist/underlayer interaction, its optical properties are significantly dependent on baking conditions. Thus, to be able to use novolac systems in a bilayer, TSI process- the chemical composition and processing conditions must be controlled as described below, otherwise significant interfacial interaction with the resist is observed limiting the ultimate resolution attained with the resist.

The thermal decomposition of the DNQ results in the formation of a highly reactive ketene intermediate that can form crosslinking ester functionalities with the phenolic sites of the matrix novolac. The crosslinking of this resin is essential to induce insolubilization and prevent dissolution during the solvent casting of the imaging layer. However, it was shown that underlayers formed from novolac/DNQ produced an interface interaction with the imaging layer that results in gross residual material or "scumming" after development. This artifact of the underlayer prohibits its use within this system.

In an effort to remedy this situation, Applicant determined that in the absence of a DNQ additive, novolac can be caused to insolubilize simply by thermal curing of a solvent-removed, spin cast film. Prolonged curing (2-5 min.) at elevated temperature (225-275 °C) is preferred. Films prepared in this manner were insoluble in common casting solvent and allowed for casting of the top imaging layer without severe mixing. The severity of the residue after development was greatly diminished as compared to the DNQ/novolac underlayer; however, some residue was persistent. Although the mechanism of this insolubilization has not been determined, it is proposed by Applicant to occur due to densification of the glassy film after prolonged heating above its glass transition temperature (T_g) coupled with a complex combination of thermally induced oxidation and/or electrophilic aromatic substitution, resulting in a crosslinked network. Evidence for these proposals lie in the dependence of the molecular weight (M_w) and

polydispersity index (PDI) of the novolac polymers and the dependence of the optical properties (n & k) on the curing conditions as shown in Example 5 in the specification.

It was found that those polymers with higher Mw values resulted in underlayers that produced . . less scumming. This was also the case with materials of higher POI. It is proposed that residue is largely caused by an interaction of the imaging layer with the underlayer. It is evident that the degree and/or efficiency of crosslinking of the underlayer greatly contribute to this deleterious phenomenon. The amount of residue clearly correlates inversely with both the Mw and the PDI of the novolac used in the formulation. Therefore, it is desirable to have a novolac of high MW and a broad PDI for minimization of residue.

The degree of crosslinking is directly dependent on 1 presence of polymeric chains of greater length, i.e. higher Mw. It also appears that the presence of lower molecular weight species is important to the degree of cross linking as the increased ratio of functionalized hydroxymethyl "end-groups to repeat groups in these oligomers is high and leads to more crosslink sites per chain. The Mw of novolac, as noted in the specification, is in the range of 2K-50K, more preferably from 2k-25K and most pre from 2k-15K.

Another problem with the novolac is that oxidation clearly occurs in these films which is apparent by the observed change in the optical density in the near UV and visual spectrum. The optical absorption dramatically increases with increased curing temperature and time, consistent with the *formation* of highly absorbing quinoidal-type species. However, since the optical properties change with a minor change in processing conditions as shown in Example 4, it is very important to tightly control the processing conditions to prevent significant variations in optical properties.

The best cross-link temperatures, as noted in the specification is between 200 and 300C, more preferably from 225-275C, and most preferably. 225-260C.

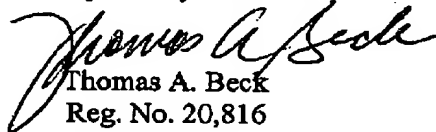
A fundamental disadvantage of the described underlayer system is in the mechanism of insolubilization, i.e., crosslinking, is not well understood. An optimum underlayer has been

designed by Applicant by including specific functional groups in combination with the polymer and formulation that can contribute a particular attribute. The formulation consists of a polymer matrix system, a thermal acid generator, and a polyfunctionalized crosslinking agent.

Each component serves its particular purpose (optical properties, insolubilization and etch properties)-on the basis of the chemical composition.

For the reasons set forth above, the instant invention is distinguishable over the prior art. Claims 1, 2 and 6 have been corrected to substitute "polyimide" for the erroneous "polyimade." Claim 3 has been canceled as the contents thereof are already included in Claim 1. Claims 9 - 17 and 19 have been withdrawn and will be the subject of a divisional application. Allowance of the application is respectfully solicited.

Respectfully Submitted,


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I certify that this amendment is being telefaxed to fax number (571) 273-8300 on the date shown below addressed to:
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